INTERNATIONAL ELECTROTECHNICAL COMMISSION

# CISPR 16-1

1999

AMENDMENT 2
2003-04

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Amendment 2

## Specification for radio disturbance and immunity measuring apparatus and methods –

## Part 1: Radio disturbance and immunity measuring apparatus

*Amendement 2*

*Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –*

*Partie 1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques*





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# FOREWORD

This amendment has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

The text of this amendment is based on the following documents:

| FDIS | Report on voting |
|---|---|
| CISPR/A/434/FDIS | CISPR/A/441/RVD |

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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CONTENTS

*Replace, on page 5, the existing title of Annex Q by the following new title:*

Annex Q (normative) Example and measurement of the parameters of an asymmetric artificial network (AAN)

*Add, on page 5, the titles of Annex Y and Annex Z as follows:*

Annex Y (normative) Performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1

Annex Z (normative) Example and measurement of the parameters of the AN for coaxial and other screened cables

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## 2 Normative references

*Insert, in the existing list, the title of the following standard:*

CISPR 14-1:2000, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

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## 3 Definitions

*Add, on page 23, the following definitions:*

**3.20**
**asymmetric artificial network (AAN)**
network used to measure (or inject) asymmetric (common mode) voltages on unshielded symmetric signal (e.g. telecommunication) lines while rejecting the symmetric (differential mode) signal

NOTE The term “Y-network” is a synonym for AAN.

**3.21**
**impedance stabilization network (ISN)**
generally an artificial network that provides a stabilized impedance to the EUT; often (e.g. in CISPR 22) used as a synonym for AAN

**3.22**
**coupling/decoupling network (CDN)**
artificial network for the measurement or injection of signals on one circuit while preventing signals from being measured or injected on another circuit

**3.23**
**longitudinal conversion loss (LCL)**
in a one- or two-port network, a measure (a ratio expressed in dB) of the degree of unwanted transverse (symmetric mode) signal produced at the terminals of the network due to the presence of a longitudinal (asymmetric mode) signal on the connecting leads
(definition from ITU-T Recommendation O.9[1])



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### 5.4 Disturbance analyzers

*Replace the existing text of 5.4 and its subclauses by the following:*

Disturbance analyzers are used for the automatic assessment of amplitude, rate and duration of discontinuous disturbances (clicks).

A ‘click’ has the following characteristics:

a) the QP amplitude exceeds the quasi-peak limit of continuous disturbance,
b) the duration is not longer than 200 ms,
c) and the spacing from a preceding or subsequent disturbance is equal to or more than 200 ms.

A series of short pulses shall be treated as a click when its duration, measured from the start of the first to the end of the last pulse, is not longer than 200 ms and conditions a) and c) are fulfilled.

The time parameters are determined from the signal which exceeds the IF reference level of the measuring receiver.

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[1] ITU-T Recommendation O.9, *Measuring arrangements to assess the degree of unbalance about earth*.

NOTE 1 Definition and assessment of clicks are in compliance with CISPR 14-1:2000.

NOTE 2 Current analyzers are designed to be used with a quasi-peak measuring receiver of the type which works with a limited internal signal level. As a result, such analyzers may not interface correctly with all receivers.

### 5.4.1 Fundamental characteristics

a) The analyzer shall be equipped with a channel to measure the duration and spacing of discontinuous disturbances; the input of this channel shall be connected to the IF output of the measuring receiver. For these measurements, only the part of the disturbance has to be considered which exceeds the IF reference level of the receiver. The accuracy of duration measurements shall be not worse than ±5 %.

NOTE 1 The IF reference level is the corresponding value in the IF output of the measuring receiver to an unmodulated sinusoidal signal, which produces a quasi-peak indication equal to the limit for continuous disturbances.

b) The analyzer shall be equipped with a channel to assess the quasi-peak amplitude of a disturbance.

c) The amplitude in the quasi-peak channel shall be measured 250 ms after the last falling edge in the IF channel.

d) The combination of both channels shall comply in all respects with the requirements of 4.1.

e) The analyzer shall be capable of indicating the following information:

- the number of clicks of duration equal to or less than 200 ms;
- the duration of the test in minutes;
- the click rate;
- the incidence of disturbances other than clicks which exceed the QP limit of continuous disturbance.

NOTE 2 An example of a disturbance analyzer is shown in form of a block diagram in Figure 11.

f) For validation of the fundamental characteristics the analyzer has to pass the performance check with all the wave forms (test pulses) in Table 13.

Figure 12 presents in a graphical form the waveforms listed in Table 13.

Figure Y.1 presents in a graphical form all the waveforms listed in Table Y.1 for the performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1.

**Table 13 – Disturbance analyzer performance test –
Test signals used for the check against the definition of a click**

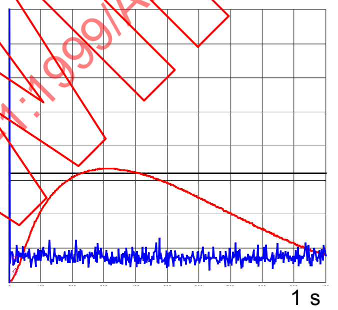
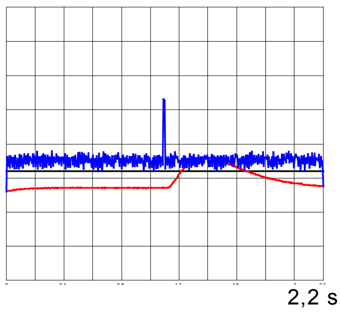
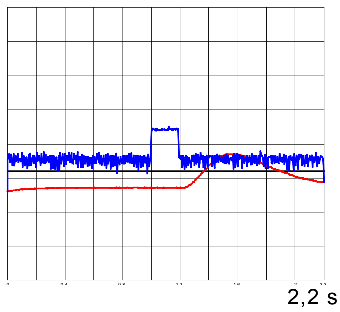
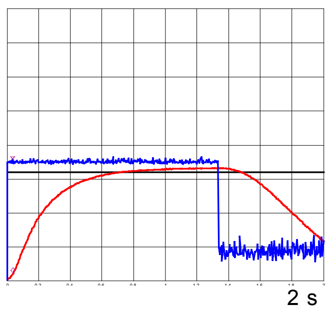
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver<br>dB | | Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver<br>ms | | Separation of impulses or periodicity (IF-output)<br>ms | Evaluation by the analyzer | Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver |
| | Pulse 1 | Pulse 2 | Pulse 1 | Pulse 2 | | | |
| 1 | 1 | | 0,11 | | | 1 click |  |
| 2 [a] | 1 | | 9,5 | | | 1 click |  |
| 3 [a] | 1 | | 190 | | | 1 click |  |
| 4 | 1 | | 1 333 [b] | | | Other than click |  |

**Table 13** (*continued*)

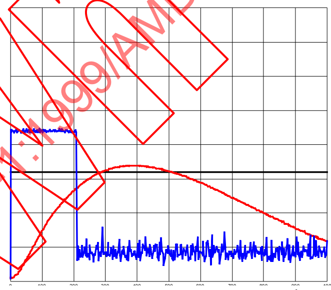
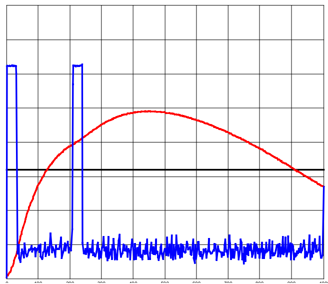
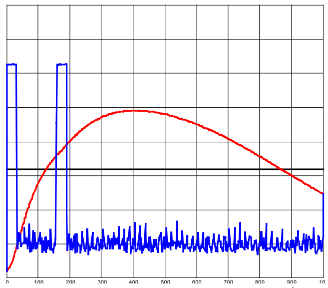
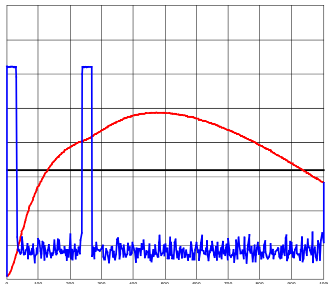
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver<br>dB | | Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver<br>ms | | Separation of impulses or periodicity (IF-output)<br>ms | Evaluation by the analyzer | Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver |
| | Pulse 1 | Pulse 2 | Pulse 1 | Pulse 2 | | | |
| 5 | 1 | | 210 | | | Other than click (210 ms) |  1 s |
| 6 | 5 | 5 | 30 | 30 | 180 | Other than click (240 ms) |  1 s |
| 7 | 5 | 5 | 30 | 30 | 130 | 1 click |  1 s |
| 8 | 5 | 5 | 30 | 30 | 210 | 2 clicks |  1 s |

**Table 13** *(continued)*

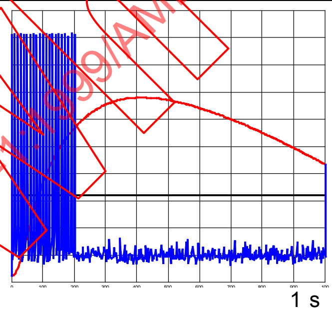
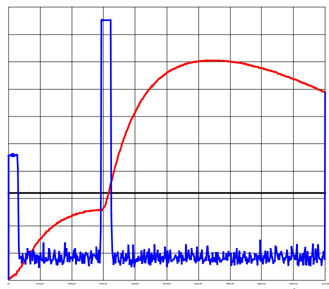
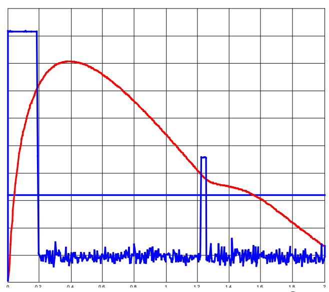
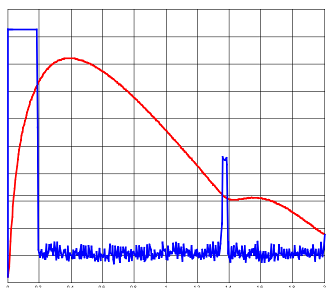
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver<br>dB | | Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver<br>ms | | Separation of impulses or periodicity (IF-output)<br>ms | Evaluation by the analyzer | Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver |
| | Pulse 1 | Pulse 2 | Pulse 1 | Pulse 2 | | | |
| 9 | 1 | | 0,11 | | Periodicity 10, min. 21 pulses | Other than click |   |
| 10 | –2,5 | 25 | 30 | 30 | 265 | 1 click |   |
| 11 | 25 | –2,5 [c] | 190 | 30 | 1 034 [e] | 2 clicks [d] |   |
| 12 | 25 | –2,5 [c] | 190 | 30 | 1 166 [e] | 1 click |   |

**Table 13** *(continued)*

[a] To be performed with background noise consisting of 200 Hz CISPR pulses at a level 2,5 dB below the quasi-peak threshold level. These pulses should be present commencing at least 1 s before the test pulse and lasting until at least 1 s after the test pulse.

Observations**:**

1) The graphical representation is done with peak measurements of a very short hold time (<1 ms) of the test receiver which show the 200-Hz pulse. When the pulse-modulated sine wave arrives, the 200-Hz-pulse is no longer visible (as seen in the graph for test no. 3) but still present during the event of the click disturbance

2) The very narrow responses at the origin in the graphs are due to a firmware imperfection.

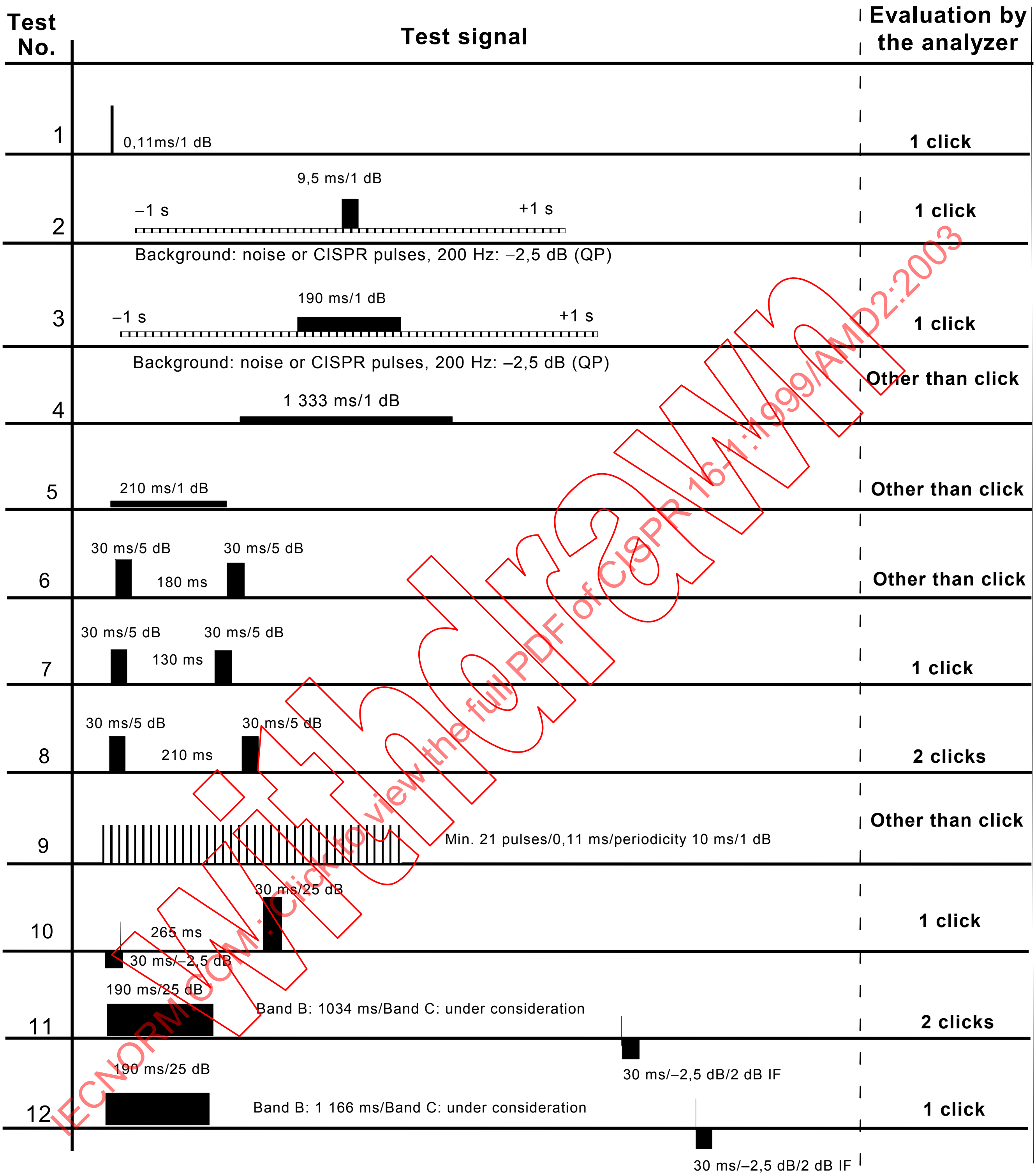
[b] The 1,333 s impulse checks the threshold of the analyzer for impulses, which are only 1 dB above the quasi-peak threshold level.

[c] These lower levels shall be set such that the intermediate frequency threshold is exceeded but the quasi-peak threshold is not exceeded

[d] If these two pulses were to be measured as separate disturbances, only one click would be registered.

[e] The correspondent values for the frequency range above 30 MHz are under consideration and will be revised after further investigations.

[f] The rise times of the pulses shall not be longer than 40 µs.




*IEC 1115/03*

**Figure 12 – A graphical presentation of test signals used in the test of the analyzer for the performance check against the definition of a click according to Table 13**

### 5.4.2 Test method for the validation of the performance check for the click analyzer

#### 5.4.2.1 Basic requirements

The disturbance analyzer is connected to the quasi-peak measuring receiver and tuned to a convenient frequency.

A CW signal and a pulsed CW signal both at the tuned frequency of the receiver are required. A signal generated by CISPR pulse generator, as defined in Annex B, with a 200 Hz PRF covering the receiver bandwidth at the tuned frequency is also required for tests No. 2 and 3.

The pulsed CW signal source shall provide two independently variable pulses. The rise time of the pulses shall be not longer than 40 µs. The pulse duration shall be variable between 110 µs and 1,3 s and the amplitudes variable over a 44 dB range. Any background noise of the pulsed CW signal source shall be at least 20 dB below the reference level used in step a) in the test measured on the receiver's quasi-peak meter.

The test procedure is as follows:

a) The CW signal is connected to the input of the measuring receiver used in conjunction with the disturbance analyzer. The amplitude of the CW signal is adjusted to bring the meter indication to the reference (zero) point on the meter scale of the measuring receiver equal to a value identical to the QP-limit for continuous disturbance. The receiver RF sensitivity (attenuator) control is adjusted to a level above the receiver noise but below the limit for continuous disturbance used as threshold in the IF channel. The corresponding level of the CW signal at the IF output of the receiver constitutes the IF reference level.

b) The pulsed CW signal is connected to the input of the measuring receiver. For test number 2 and 3 the signal from the CISPR pulse generator is added to the pulsed CW signal. The parameters of the signal are given in Table 13. The amplitudes of the pulses shown in column 1 of Table 13 are adjusted individually relative to the indication of the limit (QP) for continuous disturbance used as threshold in the IF channel. The levels shall be relative to the respective RF and IF reference levels established in the previous paragraph.

#### 5.4.2.2 Additional requirements

The test method is identical to the one described in 5.4.2.1.

The parameters of the signal are given in Table Y.1.

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#### 5.5.3.2 Magnetic antenna

*Add, after the existing paragraph, the following new paragraph:*

Tuned electrically balanced loop antennas may be used to make measurements at lower field strengths than untuned electrically-screened loop antennas.

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*Replace subclause 5.5.4.2 by the following new subclause:*

#### 5.5.4.2 Balance of antenna

##### 5.5.4.2.1 Introduction

In radiated emission measurements, common-mode (CM) currents may be present on the cable attached to the receiving antenna (the antenna cable). In turn, these CM currents create EM fields which may be picked up by the receiving antenna. Consequently, the radiated emission measuring results may be influenced.

The major contributions to the antenna cable CM currents stem from

a) the electric field generated by the EUT, if that field has a component parallel to the antenna cable, and
b) the conversion of the differential mode (DM) antenna signal (the desired signal) into a CM signal by the imperfection of the balun of the receiving antenna.

This subclause considers the balun contribution. Contribution a) is under consideration (see last sentence of NOTE 1 of 5.5.4.2.2).

In general, log-periodic dipole array antennas do not exhibit significant DM/CM conversion and the following check applies to dipoles, biconical antennas and bicone/log hybrid antennas.

##### 5.5.4.2.2 Balun DM/CM conversion check

The following method describes the measurement of two voltages, $U_1$ and $U_2$, in the frequency range for which the receiving antenna is to be used. The ratio of these voltages, both expressed in identical units (e.g., dBμV), is a measure for the DM/CM conversion.

1) Set the receiving antenna under test vertically polarized with its centre at a height of 1,5 m above the ground plane. Lay the cable horizontally for 1,5 m ± 0,1 m behind the rear active element of the antenna and then drop it vertically by a height of at least 1.5 m to the ground plane.
2) Place a second (transmitting) antenna vertically polarized at a horizontal distance of 10 m from the centre of the antenna under test with its tip 0,10 m from the ground plane. If the range of the site used for emission testing is 3 m, do this check using a distance of 3 m (if the conversion check has already been made at 10 m distance and shows a change of less than ±0,5 dB, it is not necessary to take a separate measurement at 3 m). The specification of the transmitting antenna shall include the frequency range of the antenna under test.
3) Connect the transmitting antenna to a signal source, for example, a tracking generator, set the level of that generator in such a way that, over the frequency range of interest, the signal-to-ambient noise at the receiver is larger than 10 dB.
4) Record the voltage $U_1$ at the receiver over the frequency range of interest.
5) Invert the receiving antenna (rotate that antenna through 180°) without changing anything else in the set-up, in particular the receiving antenna cable, and without changing the setting of the signal source.
6) Record the voltage $U_2$ at the receiver over the frequency range.
7) The DM/CM conversion is sufficiently low if $|20 \log (U_1/U_2)| < 1$ dB.

NOTE 1 If the DM/CM conversion criterion is not met, ferrite rings around the antenna cable may reduce the DM/CM conversion. The addition of ferrites on the antenna cable may also be used to verify whether contribution a) has a non-negligible effect. Repeat the test with four ferrites spaced approximately 20 cm apart. If the criterion is met by using these rings, they shall be present in the actual emission measurement. Likewise, the interaction with the cable can be reduced by extending the cable several metres behind the antenna before dropping to ground.

NOTE 2 If the receiving antenna is to be used in a fully anechoic chamber, the DM/CM check may be performed in that room with the receiving antenna at its usual location and the transmitting antenna in the centre of the test volume of that room. The room must comply with the ±4 dB criterion

NOTE 3 The measuring site of which the ground plane forms a part, or the fully anechoic room, should comply with their respective NSA requirements.

NOTE 4 The horizontal distance of 1,5 m over which the antenna cable runs horizontally behind the centre of the antenna shall be kept as a minimum during actual vertically polarized radiated emissions measurements.

NOTE 5 It is not necessary to define a test set-up strictly because this effect is in large part due to the interaction of the antenna and the part of input cable that lies parallel to the antenna elements. There is a much smaller effect which is dependent on the uniformity of the field incident on the antenna in normal EMC set-ups on an OATS or in a fully anechoic room.

NOTE 6 For baluns which have the receive cable connector mounted on the side (90° to the antenna boom), a right angle connector should be used to reduce the movement of the cable.

*Add the following new subclause 5.5.4.3:*

### 5.5.4.3 Cross-polar performance of antenna

When an antenna is placed in a plane-polarized electromagnetic field, the terminal voltage when the antenna and field are cross-polarized shall be at least 20 dB below the terminal voltage when they are co-polarized. It is intended that this test apply to log-periodic dipole array (LPDA) antennas for which the two halves of each dipole are in echelon. The majority of testing with such antennas is above 200 MHz, but the requirement applies below 200 MHz. This test is not intended for in-line dipole and biconical antennas because a cross-polar rejection greater than 20 dB is intrinsic to their symmetrical design. Such antennas and horn antennas must have a cross-polar rejection greater than 20 dB and a type test by the manufacturer should confirm this.

In order to achieve quasi-free space conditions, a high-quality anechoic chamber or towers of sufficient height above ground on an outdoor range can be used. To minimize ground reflections set the antennas vertically polarized. A plane wave shall be set up at the antenna under test. The separation between the centre of the antenna under test and the source antenna shall be greater than one wavelength.

NOTE 1 A good-quality site is needed to set up a plane wave at the antenna under test. The cross-polar discrimination afforded by the plane wave can be proven by transmitting between a pair of horn antennas or open-ended waveguides and checking that the combination of site error and inherent cross-polar performance of one horn antenna yields a suppression of the horizontal component by more than 30 dB. If the site errors are very low and if the horn antennas have identical performance, the cross-polar performance of one horn is approximately 6 dB lower than the combined cross-polar coupling of the pair of horns.

An interfering signal 20 dB lower in level than the desired signal gives a maximum error on the desired signal of ±0,9 dB. The maximum error occurs when the cross-polar signal is in phase with the co-polar signal. If the cross-polar response of the LPDA is worse than 20 dB, the operator must calculate the uncertainty and declare it with the result, for example a cross-polar level of 14 dB implies a maximum uncertainty of +1,6 dB to –1,9 dB. Take the larger value and assume a U-shaped distribution when calculating the standard uncertainty.

To add a signal of 0 dB to another of –14 dB, first convert to relative voltages by dividing by 20 and taking the anti-log. Then add the smaller signal to the unity signal. Take the log and multiply by 20. The result is the positive decibel error. Repeat, but subtracting the smaller signal from the unity signal to give the negative decibel error.

For the purpose of calculating the uncertainty of the result of a radiated emission, if the signal level measured in one polarization exceeds the signal measured in the orthogonal polarization by 6 dB or more, then an LPDA whose cross-polar discrimination is only 14 dB will have been deemed to have met the specification of 20 dB. If the difference between the VP and HP signal levels is less than 6 dB, additional uncertainty must be calculated if the sum of this difference and the cross-polarization is less than 20 dB.

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### 5.10 Coupling devices for measuring signal lines

*Replace the existing text of this subclause by the following new text:*

The interference potential (and immunity) of signal lines may be assessed by measurement (or injection) of the conducted disturbance voltage or current. For this purpose coupling devices are needed to measure the disturbance component while rejecting the intentional signal on the line. The devices included are to measure the electromagnetic emission and immunity (common and differential mode, current and voltage). Typical devices for these kinds of measurements are current probes and asymmetric artificial networks (AANs or Y-networks).

NOTE 1 Requirements for AANs for conducted immunity tests on signal lines may be found in IEC 61000-4-6[2)] (AANs are special versions of "coupling and decoupling devices" [so called coupling/decoupling networks (CDNs)]). An AAN which meets the requirement for emission measurements may also meet the requirements for immunity testing.

NOTE 2 Signal lines include telecommunication lines and terminals of equipment intended to be connected to these lines.

NOTE 3 The terms "asymmetric voltage" and "common mode voltage" as well as "symmetric voltage" and "differential mode voltage" are synonyms, as defined in Clause 3.

NOTE 4 The term "asymmetric artificial network (AAN)" is used as synonym for "Y-network", which is in contrast to V-networks and Δ-networks. The T-network is a special version of the Y-network.

When a current probe is used and the limit value is specified in volts, the voltage value must be divided by the impedance of the signal line or termination impedance as specified by the detailed measurement procedure, to obtain the limit value for the current. This impedance may be common mode as required by the detailed measurement procedure.

Subclause 5.10.1 states the specification for asymmetric (common mode) artificial networks (AANs). The differential mode to common mode rejection ($V_{dm}/V_{cm}$) is crucial to the useability of the AAN. This parameter is related to the longitudinal conversion loss (LCL). An example of asymmetric artificial networks and the required test and calibration procedures are given in Annex Q.

#### 5.10.1 Requirements for asymmetric artificial networks (AANs or Y-networks)

Asymmetric artificial networks (AANs) are used to measure (or inject) asymmetric (common mode) voltages on unshielded symmetric signal (e.g. telecommunication) lines while rejecting the symmetric (differential mode) signal.

NOTE In CISPR 22 this type of network is called impedance stabilization network (ISN).

Figure 52a shows the general circuit diagram of an asymmetric artificial network.

The characteristics of the AAN for the measurement of asymmetric (common mode) disturbances shall be covering the frequency range of the asymmetric disturbance voltages as well as the frequency range used for the transmission of the intentional signal. These characteristics are given in Table 18.

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[2)] IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*

**Table 18 – Characteristics of the asymmetric artificial network for the measurement of asymmetric disturbance voltage**

| | | |
|---|---|---|
| a. | **Termination impedance** of basic network for asymmetric disturbance voltage[a]<br>• magnitude<br>• phase | <br><br>150 Ω ± 20 Ω<br>0° ± 20° |
| b. | **Longitudinal conversion loss (LCL) at the EUT port** of the network[b] | (9 kHz to 150 kHz: to be defined)<br>0,15 MHz to 30 MHz: defined by the relevant product standard, e.g. as shown in Figure 52b[c] |
| c. | **Decoupling attenuation** for asymmetric signals between AE port and EUT port. | (9 kHz to 150 kHz: to be defined)<br>0,15 MHz to 1,5 MHz:<br>>35 dB to 55 dB increasing linearly with the log. of frequency<br>>1,5 MHz: > 55 dB |
| d. | **Insertion loss of the symmetric circuit** between EUT and AE ports | <3 dB[d] |
| *e.* | **Voltage division factor of the asymmetric circuit** between EUT and measuring receiver ports, to be added to the reading of the measuring receiver. | Typically 9,5 dB[e] |
| f. | **Symmetric load impedance** of the network | t.b.d.[f] |
| g. | **Transmission bandwidth** for the intentional signal (analog or digital) | t.b.d.[g] |
| h. | **Frequency range**[h] (1) Emission<br>(2) Immunity | (0,009) 0,15 MHz to 30 MHz<br>See e.g. IEC 61000-4-6 |

[a] The asymmetric impedance of the AAN will normally be influenced by the addition of an unbalanced network according to Figure 52a. This standard specifies the impedance tolerance for the basic network. If the influence of the unbalanced network on impedance and phase is negligible, the given tolerance may apply including the unbalanced network. If this is not the case, e.g. if the unbalanced network changes the impedance by more than 10 Ω or the phase by more than 10°, the product standard shall take this into account when specifying tolerances for impedance and phase, since a certain tolerance should be left to the AAN manufacturer.

[b] Different concepts for determination of conformance of equipment are in use: use an LCL of the AAN higher than the available LCL values of signal lines or use the LCL to simulate available telecommunication line categories.

[c] The values of LCL in Figure 52b have been taken – with modified tolerances – from a draft of the amendment to CISPR 22:1997. Other values may be defined by future product standards. Therefore the LCL requirements given in this publication are examples only. Generally, 3 factors have to be considered for LCL tolerances: the residual LCL of the basic AAN, the deviation of the unsymmetry network $Z_{un}$ from nominal and the uncertainty of LCL measurement. The tolerances given in a product standard should take into account that acceptable tolerances should increase with the required LCL and with frequency. Figure 52b shows an example of reasonable tolerances.

[d] The actual requirements will depend on the specifications of the transmission system. Some transmission systems allow insertion losses of up to 6 dB. The insertion loss caused by an AAN is dependent on source and load impedances of the whole symmetric circuit. For lower/higher impedances the insertion loss will be lower/higher, and should be given by the manufacturer, e.g. for 100 Ω. In addition, it will be useful if manufacturers specify the phase characteristics of the AAN in its symmetric circuit.

[e] The AAN shall be calibrated by measuring the voltage division factor in a test set-up according to Figure Q.6

[f] t.b.d. = to be defined, i.e. depending on the system specifications, e.g. 100 Ω or 600 Ω

[g] t.b.d. = to be defined, i.e. depending on the system specifications for the symmetric insertion loss, e.g. up to 2 MHz or up to 100 MHz

[h] More than one network may be used to cover the complete frequency range.

### 5.10.2 Requirements for artificial networks for coaxial and other screened cables

Artificial networks for coaxial and other screened cables are used to measure (or inject) unsymmetric (common mode) voltages on the shield of (e.g. telecommunication or r.f.) cables while passing the communication or r.f. signal through. The required characteristics are given in Table 22.

NOTE 1 In CISPR 22 this type of network is called coaxial or screened cable impedance stabilization network (ISN).

**Table 22 – Characteristics of artificial networks for coaxial and other screened cables**

| | | |
|---|---|---|
| a. | **Termination impedance** of basic network for unsymmetric disturbance voltage:[a]<br>• magnitude<br>• phase | <br><br>150 Ω ± 20 Ω<br>0° ± 20° |
| b. | **Decoupling attenuation**[b] for unsymmetric signals between AE port and EUT port. | (9 kHz to 150 kHz: to be defined)<br>0,15 MHz to 30 MHz: >40 dB |
| c. | **Insertion loss and transmission bandwidth** for the intentional (communication or r.f.) signal between EUT and AE ports, including **characteristic impedance(s)** | Defined by system requirements[c] |
| d. | **Voltage division factor of the unsymmetric circuit** between EUT and measuring receiver ports, to be added to the reading of the measuring receiver. | Typically 9,5 dB[d] |
| e. | **Frequency range** (1) Emission<br>(2) Immunity | (0,009) 0,15MHz to 30 MHz<br>See e.g. IEC 61000-4-6 |

[a] The asymmetric impedance of the AN will be determined by the 150-Ω resistor in parallel with the choke and the capacitance of the bulkhead connector to ground.

[b] Since the coaxial cable shield at the AE port is directly connected to the AN metal case, the decoupling attenuation will not be a problem of the AN itself. The emission (or immunity) test set-up shall be so that the minimum decoupling attenuation can be guaranteed.

[c] Insertion loss and transmission bandwidth for the intentional (communication or r.f.) signal between EUT and AE ports as well as the characteristic impedances between shield and inner conductor(s) are not the purpose of this standard. They should be defined according to system requirements.

[d] The AN shall be calibrated by measuring the voltage division factor in a test set-up according to Figure Z.2.

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*Replace the existing Annex Q by the following:*

# Annex Q
(normative)

# Example and measurement of the parameters of the asymmetric artificial network (AAN)

## Q.1 Description of an example of an AAN: the T-network

Figure Q.1 gives an example of an AAN, the T-network, having terminals $a_1$ and $b_1$ for connection to a conductor pair in a signal port of an EUT and RG for connection to the reference ground and, if applicable, to the safety earth or other ground connector of the EUT.

The symmetric signal which may be needed to have the EUT operating correctly is connected to the terminals $a_2$ and $b_2$. The double choke $L_1$ allows separate measurement of the asymmetric component of the disturbance. The two windings are designed such that the symmetric currents are suppressed by a high impedance whereas the impedance for asymmetric currents (passing to $R_M$) shall be negligible.

The termination impedance of the network for the asymmetric disturbance voltage of 150 Ω is determined by the two resistors $R_T$ (200 Ω), in parallel for the asymmetric current, in series with the resistor $R_M$ (50 Ω). The resistor $R_M$ is usually the input impedance of a measuring receiver. In this case the meter reading is typically 9,5 dB lower than the actual asymmetric value at the terminal of the EUT. The capacitor $C_T$ is blocking d.c. currents thus allowing for d.c. supply voltages on the network leads without damaging the resistors and without affecting the properties of $L_1$, due to saturation.

Normally an AAN is inserted between an EUT and its associated equipment.

## Q.2 Measurements of the parameters of an asymmetric artificial network (AAN)

For the determination of compliance with the requirements of 5.10.1, the procedures for the measurement of the specified parameters described below are used.

a) **Termination impedance**

This impedance between the terminals $a_1$ and $b_1$ connected together, and terminal RG shall be checked with terminals $a_2$ and $b_2$ being alternatively open and short-circuited to the earth terminal RG (see Figure Q.2).

b) **Longitudinal conversion loss (LCL)**

This rejection of the Y-network shall be measured in accordance with Figure Q.3c. The network analyzer (NWA), applies its output signal to an LCL probe, which must have a residual longitudinal conversion loss (LCL) at least 10 dB higher than the required LCL of the AAN. For LCL probe verification, see Figure Q.3a and for calibration, see Figure Q.3b.

c) **Decoupling attenuation**

The decoupling attenuation shall be measured in accordance with Figure Q.4.

d) **Insertion loss of the symmetric circuit**

The insertion loss of the symmetric circuit shall be measured in accordance with Figure Q.5.

Two LCL probes can be used as baluns for the insertion loss test of the Y-network. Two identical baluns may be connected in series for the determination of their own insertion loss. Baluns can be designed such that the combined insertion loss of 2 baluns is less than 1 dB in the frequency range from 0,15 MHz to 30 MHz.

e) **Voltage division factor of the asymmetric circuit (calibration of the Y-network)**

The voltage division factor of the asymmetric circuit shall be measured in accordance with Figure Q.6.

f) **Symmetric load impedance and transmission bandwidth**

This parameter is defined by the system. Y-networks may be optimized for a certain impedance with respect to transmission bandwidth. The transmission bandwidth may be measured for a certain symmetric load impedance using the test set-up of Figure Q.5.

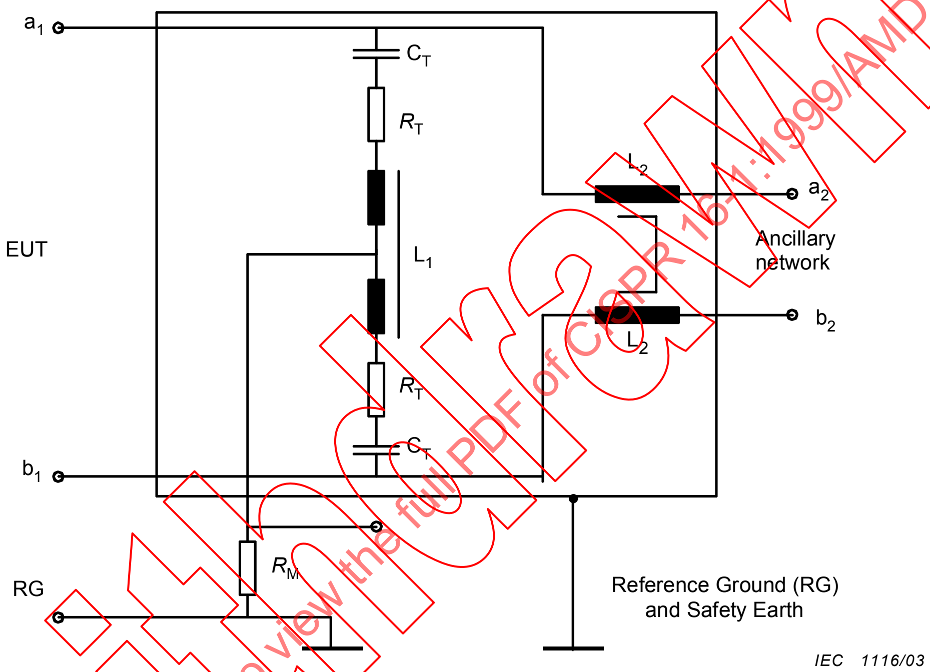
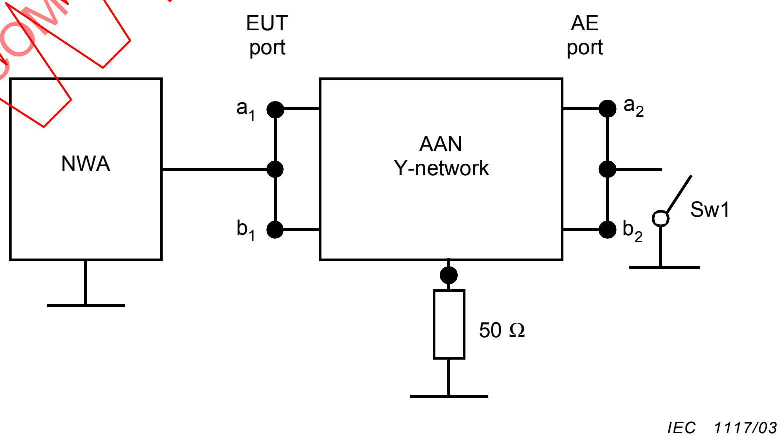
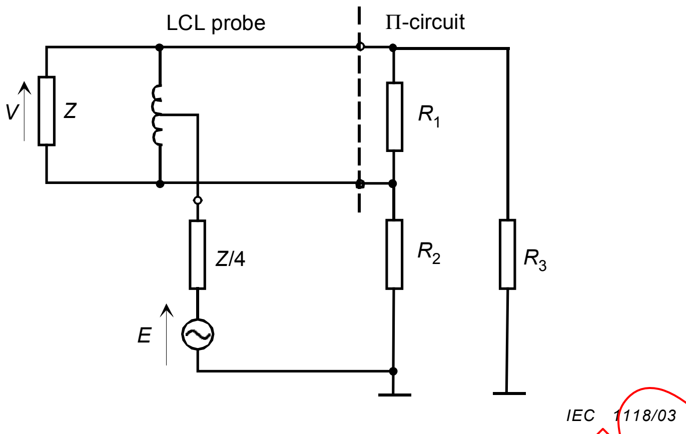



**Figure Q.1 – Example of a T-network circuit for one pair of wires**




NOTE If the AAN is of higher order (i.e. more than 1 pair of wires), then all wires of the EUT port, respectively all wires of the AE port, are connected together.

**Figure Q.2 – Arrangement for the termination impedance measurement**




NOTE When terminated with a minimum LCL Π-circuit consisting of $R_1$, $R_2$ and $R_3$ ($R_2$ = $R_3$) which include both the nominal symmetric impedance $Z$ ($= \frac{R_1 \cdot (R_2 + R_3)}{R_1 + R_2 + R_3}$) of the AAN and the asymmetric impedance of 150 Ω ($= \frac{R_2 \cdot R_3}{R_2 + R_3}$). The probe should ideally show a residual LCL of 20 dB or higher than the highest LCL to be measured. For $Z$ = 100 Ω: $R_1$ = 120 Ω and $R_2$ = $R_3$ = 300 Ω.

The LCL probe should be operated with an asymmetric source impedance of $Z/4$.

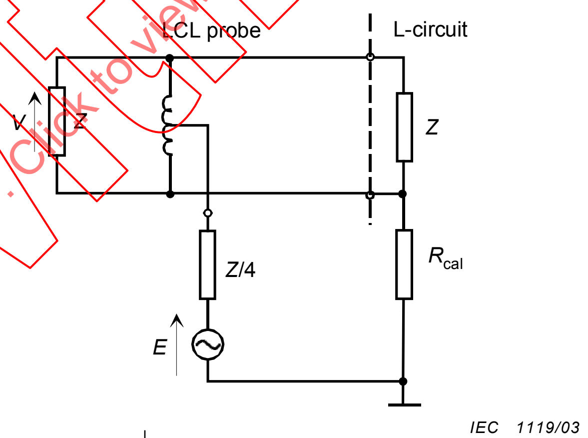
For $Z$ = 100 Ω, $Z/4$ equals 25 Ω.

For optimum reproducibility, the LCL of the probe should be maximized for both orientations of the π-circuit relative to the balanced terminals of the LCL probe.

Definition: longitudinal conversion loss (LCL) $= 20 \lg \left| \frac{E}{V} \right|$ in dB (according to ITU-T Recommendation. G.117)

The LCL probe should be so constructed that the LCL can be measured using ordinary network analyzers. An example LCL probe is described in [1][3].

**Figure Q.3a – Arrangement for the LCL probe verification**



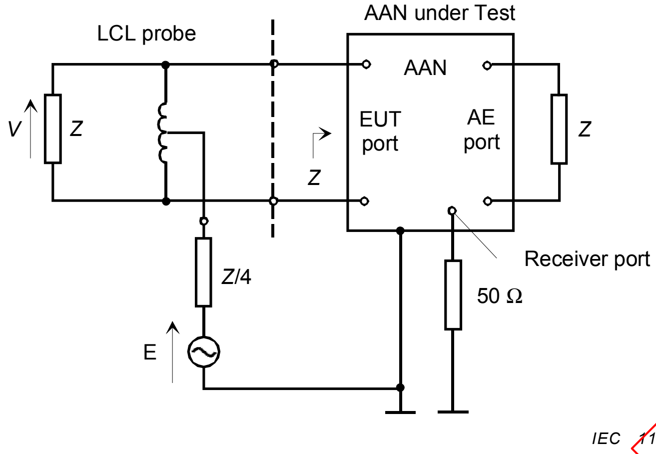

NOTE $LCL_L = 20 \lg \left| \frac{(R_{sym} // Z) + 4R_{cal} + Z}{2(R_{sym} // Z)} \right| \mathrm{dB}$

The LCL measurement uncertainty per Figure Q.3c is influenced by the accuracy of the L-circuit and the amount of the residual LCL of the probe. Changing the orientation of the LCL probe relative to the L-circuit will show some uncertainty of calibration.

Example of an L-circuit: For an impedance $Z$ = 100 Ω and $R_{sym}$ = 100 Ω, a value $R_{cal}$ = 750 Ω will give an LCL of 29,97 dB i.e. approximately 30 dB.

**Figure Q.3b – Test arrangement for the LCL probe calibration (L-circuit)**

[3] Figures in brackets refer to the reference documents at the end of this annex.




NOTE 1 For the definition of LCL see Figure Q.3a.

NOTE 2 Depending on the closeness between the LCL to be measured and the residual LCL of the probe, a measurement with both orientations of the LCL probe, relative to the EUT port terminals and the determination of the mean value of the two results, may improve the accuracy of the test.

NOTE 3 If the AAN is of higher order (i.e. more than 1 pair of wires), then the LCL of each pair is tested, while the other pair(s) is (are) terminated with the common mode impedance *Z* in case of any influence on the measured pair.

**Figure Q.3c –Test arrangement for the LCL measurement of the AAN**

**Figure Q.3 – LCL measurement using an LCL probe including verification and calibration of the probe**

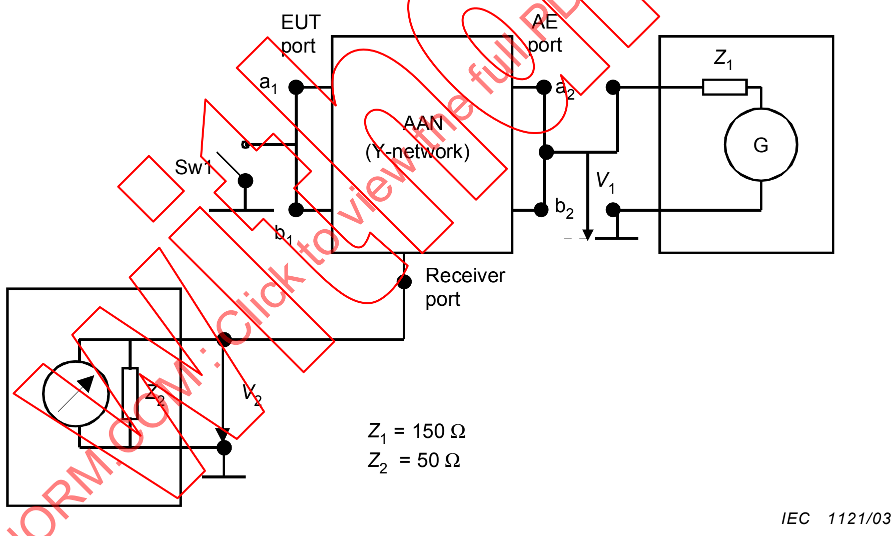
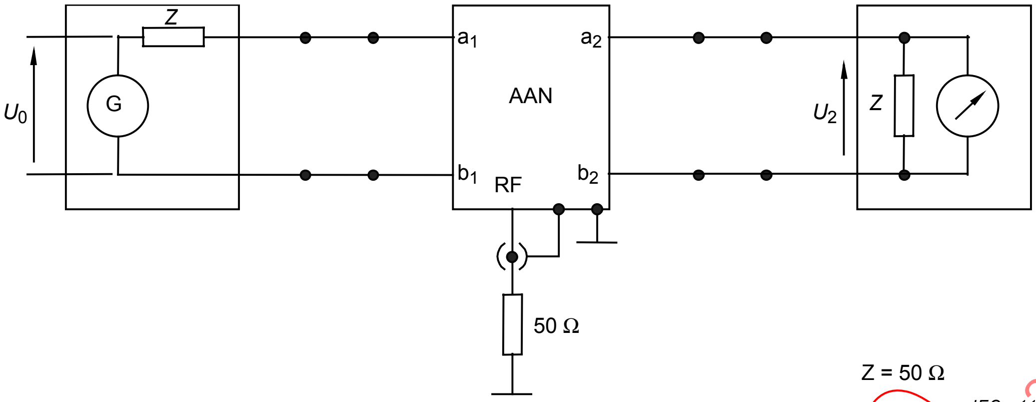



**Figure Q.4 – Test set-up for the decoupling attenuation (isolation) of the AAN**

$$a_{\text{decoup}} = 20\ \lg\left|\frac{V_1}{V_2}\right| - a_{\text{vdiv}} \quad \text{in dB}$$

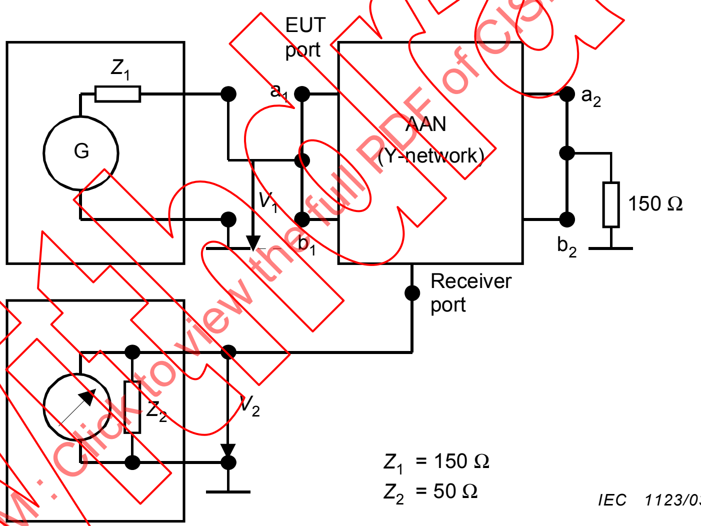
**for asymmetric signals between AE port and EUT port**




The decoupling attenuation specification shall be met in both positions of Sw1 (short and open). If the AAN is of higher order (i.e. more than 1 pair of wires), then all wires of the EUT port respectively all wires of the AE port are connected together. $a_{vdiv}$ is the voltage division factor as measured in accordance with Figure Q.6.

NOTE If the AAN is of higher order (i.e. more than 1 pair of wires), then each pair shall be tested separately.

**Figure Q.5 – Test set-up for the insertion loss (symmetric) of the AAN**




NOTE If the AAN is of higher order (i.e. more than one pair of wires), then all wires of the EUT port respectively all wires of the AE port are connected together.

**Figure Q.6 – Calibration test set-up for the AAN voltage division factor of the asymmetric circuit: $a_{vdiv} = 20\lg\left|\frac{V_1}{V_2}\right|$ in dB**

## Q.3 Reference documents

[1] MACFARLANE, IP. A Probe for the Measurement of Electrical Unbalance of Networks and Devices. *IEEE Trans. EMC*, Feb. 1999, Vol.41, No.1, p.3-14.

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*Add, after Annex W, the new Annexes Y and Z as follows:*

# Annex Y
(normative)

## Performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1

For the application of the exceptions given in CISPR 14-1:2000 the disturbance analyzer shall provide the following additional information:

a) the number of clicks of duration equal to or less than 10 ms;

b) the number of clicks of duration greater than 10 ms but equal to or less than 20 ms;

c) the number of clicks of duration greater than 20 ms but equal to or less than 200 ms;

d) the duration of each registered disturbance the amplitude of which exceeds the QP level limit for cont. disturbance;

e) an indication that the appliance failed the test, if it is clear that it produces disturbances other than clicks not corresponding to the definition of a click and to which none of the exceptions can be applied;

f) the time interval from the start of the test to the occurrence of disturbances; mentioned under e);

g) the total duration of disturbances other than clicks the QP level limit of which exceeds the limit for continuous disturbance;

h) the click rate.

**Table Y.1 – Disturbance analyzer test signals** [a]

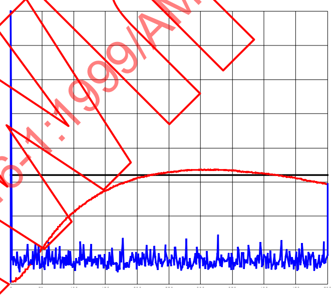
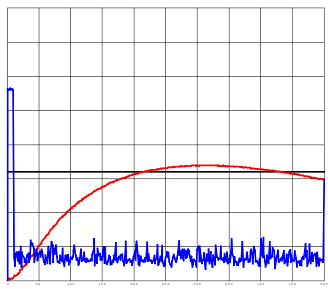
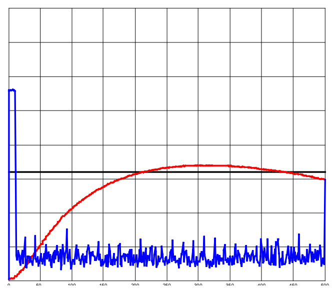
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver<br>dB | | Duration of impulses [b] adjusted in the intermediate frequency output of the measurement receiver<br>ms | | Separation of impulses or periodicity (IF-output)<br>ms | Evaluation by the analyzer | Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver |
| | Pulse 1 | Pulse 2 | Pulse 1 | Pulse 2 | | | |
| 1 | 1 | | 0,11 | | | 1 click<br><= 10 ms | <br>500 ms |
| 2 | 1 | | 9,5 | | | 1 click<br><= 10 ms | <br>500 ms |
| 3 | 1 | | 10,5 | | | 1 click<br>> 10 ms,<br><= 20 ms | <br>500 ms |

**Table Y.1** (*continued*)

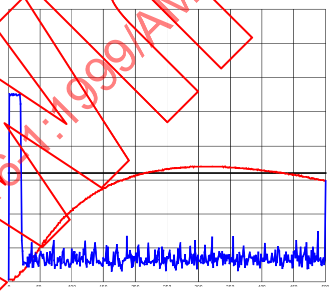
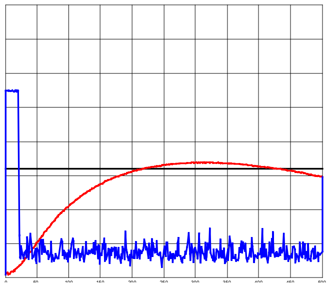
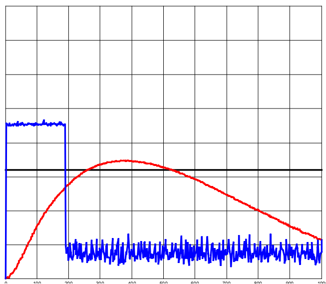
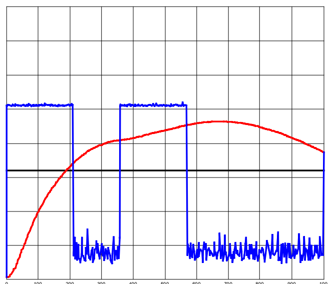
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | **QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver**<br>dB | | **Duration of impulses [b] adjusted in the intermediate frequency output of the measurement receiver**<br>ms | | **Separation of impulses or periodicity (IF-output)**<br>ms | **Evaluation by the analyzer** | **Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver** |
| | **Pulse 1** | **Pulse 2** | **Pulse 1** | **Pulse 2** | | | |
| 4 | 1 | | 19 | | | 1 click<br>> 10 ms,<br><= 20 ms | <br>500 ms |
| 5 | 1 | | 21 | | | 1 click<br>> 20 ms | <br>500 ms |
| 6 | 1 | | 190 | | | 1 click<br>> 20 ms | <br>1 s |
| 7 | 5 | 5 | 210 | 210 | 150 | **IF**<br>only once per program cycle or per minimum observation time: counted as<br>1 click >20 ms (see NOTE 2, E2, 600 ms rule) | <br>1 s |
| | | | | | | **OTHERWISE**<br>Continuous disturbance (570 ms) | |

**Table Y.1** (*continued*)

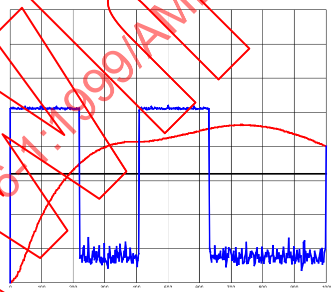
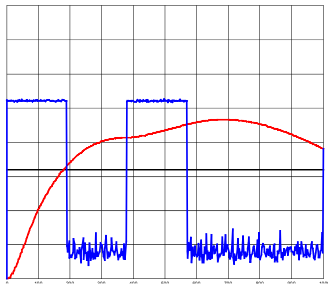
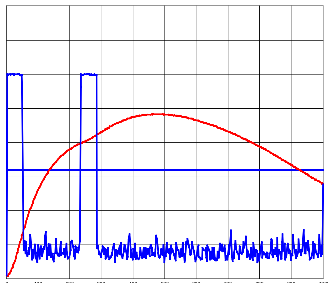
| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver<br>dB | | Duration of impulses [b] adjusted in the intermediate frequency output of the measurement receiver<br>ms | | Separation of impulses or periodicity (IF-output)<br>ms | Evaluation by the analyzer | Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver |
| | Pulse 1 | Pulse 2 | Pulse 1 | Pulse 2 | | | |
| 8 | 5 | 5 | 220 | 220 | 190 | **FAIL**<br>Continuous disturbance<br>(See NOTE 2, E2: no exception is applicable because the total duration is 630 ms > 600 ms) | <br>1 s |
| 9 | 5 | 5 | 190 | 190 | 190 | **IF**<br>the final click rate is less than 5:<br>2 clicks >20 ms<br>(see NOTE 2, E4; refrigerator rule; also see NOTE 3) | <br>1 s |
| | | | | | | **OTHERWISE IF**<br>only once per program cycle or once during the minimum observation time: counted as 1 click >20 ms (see NOTE 2, E2)<br>**OTHERWISE**<br>Fail: continuous disturbance (570 ms) | |
| 10 | 5 | 5 | 50 | 50 | 185 | **IF**<br>the final click rate is less than 5:<br>2 clicks >20 ms<br>(see NOTE 2, E4; also see NOTE 3) | <br>1 s |

**Table Y.1** (*continued*)

| Test No. | Test signal parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | 4 | 5 |
| | **QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver**<br>dB | | **Duration of impulses** [b] **adjusted in the intermediate frequency output of the measurement receiver**<br>ms | | **Separation of impulses or periodicity (IF-output)**<br>ms | **Evaluation by the analyzer** | **Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver** |
| | **Pulse 1** | **Pulse 2** | **Pulse 1** | **Pulse 2** | | | |
| | | | | | | **OTHERWISE IF**<br>not more than once per program cycle or during the minimum observation time: counted as 1 click < 600 ms<br>(see NOTE 2, E2, 2×285 ms >20 ms)<br>**OTHERWISE**<br>fail: continuous disturbance (285 ms) | |
| 11 | 20 | 20 | 15 | 5 | 1 × Pulse 1 + 9 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s | 36 clicks < 10 ms<br>4 clicks > 10 ms, <= 20 ms<br>>= **90 %** of the clicks < 10 ms<br>**PASS**<br>(see NOTE 2, E3; also see NOTE 4;<br>a measurement of the click amplitudes is **not** required.) | |
| 12 | 20 | 20 | 15 | 5 | 1 × Pulse 1 + 8 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s | 35 clicks < 10 ms<br>5 clicks > 10 ms, <= 20 ms<br>< **90 %** of the clicks < 10 ms<br>(see NOTE 2, E3; also see NOTE 4.<br>No exception is applicable.<br>**After application of upper quartile method the final result will be "FAIL"** because the click amplitudes are too high.) | |

NOTE 1 CISPR 14-1:2000, 4.2.3, contains the following exceptions:

- E1 – "Individual switching operations"
  This exception can be evaluated only by the operator, not automatically by the disturbance analyzer. It is mentioned here to avoid confusion with the numbering of the exceptions for users of both CISPR 16-1 and CISPR 14-1.
- E2 – "Combination of clicks in a time frame less than 600 ms" ("600 ms rule")
  In program-controlled appliances a combination of clicks in a time frame less than 600 ms is allowed once per selected program cycle. For other appliances such a combination of clicks is allowed once during the minimum observation time. This is also valid for thermostatically controlled three-phase switches, causing three disturbances sequentially in each of the three phases and the neutral. The combination of clicks is considered as one click.
- E3 – "Instantaneous switching"
  Appliances which fulfil the following conditions:
  – the click rate is not more than 5,
  – none of the caused clicks has a duration longer than 20 ms, and
  – 90% of the caused clicks have a duration less than 10 ms,
  shall be deemed to comply with the limits, independent of the amplitude of the clicks. If one of these conditions is not satisfied then the limits for discontinuous disturbance apply.